CLAIMS

1. A semiconductor device comprising:

a substrate; and

a gallium nitride material region formed over the substrate,

wherein the semiconductor device has at least one via extending from a first side of the semiconductor device, wherein the via is free of an electrical contact formed therein.

2. The semiconductor device of claim 1, wherein the via extends from a backside of the semiconductor device.

3. The semiconductor device of claim 1, wherein the via extends from a backside of the substrate.

4. The semiconductor device of claim 1, further comprising a first topside electrical contact.

5. The semiconductor device of claim 4, further comprising a second topside electrical contact.

6. The semiconductor device of claim 4, wherein the first topside electrical contact is formed on a first topside portion and a second topside electrical contact is formed on a second topside portion, wherein the first topside portion and the second topside portion are on different planes.

7. The semiconductor device of claim 5, further comprising a third topside electrical contact.

8. The semiconductor device of claim 1, wherein the gallium nitride material region includes a reflector region.

9. The semiconductor device of claim 8, wherein the light-reflective region comprises a Distributed Bragg Reflector.

10. The semiconductor device of claim 8, wherein the reflector region is formed, at least in part, within the via.

11. The semiconductor device of claim 10, wherein the reflector region comprises a metal layer.

12. The semiconductor device of claim 1, wherein the via is free of any material formed therein.

13. The semiconductor device of claim 1, wherein the via provides access to a layer formed on the substrate.

14. The semiconductor device of claim 1, wherein the via has a truncated pyramid shape.

15. The semiconductor device of claim 1, wherein the cross-sectional area of the via decreases in a direction away from the backside of the silicon substrate.

16. The semiconductor device of claim 1, wherein the cross-sectional area of the via increases in a direction away from the backside of the silicon substrate.

17. The semiconductor device of claim 1, wherein the semiconductor device is a light-emitting device.

18. The semiconductor device of claim 17, wherein the light emitting device is mounted on a reflective surface.

19. The semiconductor device of claim 17, wherein light is emitted through the via.

20. The semiconductor device of claim 17, wherein light is emitted through a topside of the semiconductor structure.

21. The semiconductor device of claim 17, wherein light is emitted through a backside of the semiconductor structure.

22. The semiconductor device of claim 17, wherein the semiconductor device is an LED.

23. The semiconductor device of claim 17, wherein the semiconductor device is a laser.

24. The semiconductor device of claim 1, further comprising a medium including phosphor.

25. The semiconductor device of claim 1, wherein the via is formed through the substrate.

26. The semiconductor device of claim 1, wherein the via extends to the gallium nitride material region.

27. The semiconductor device of claim 1, wherein the semiconductor device has more than one via extending from a first side of the semiconductor device.

28. The semiconductor device of claim 1, wherein a backside of the semiconductor device is free of an electrical contact.

29. The semiconductor device of claim 1, wherein the substrate is a silicon substrate.

30. The semiconductor device of claim 1, wherein the semiconductor device comprises a FET.

31. The semiconductor device of claim 1, further comprising a compositionally-graded transition layer formed between the substrate and the gallium nitride material region.

32. The semiconductor device of claim 31, further comprising a constant composition transition layer formed between the substrate and the compositionally-graded transition layer, the constant composition transition layer comprising a gallium nitride alloy, aluminum nitride, or an aluminum nitride alloy.

33. The semiconductor device of claim 31, further comprising a constant composition transition layer formed between the compositionally-graded transition layer and the gallium nitride material region, the constant composition transition layer comprising a gallium nitride alloy, aluminum nitride, or an aluminum nitride alloy.

34. The semiconductor device of claim 1, wherein the gallium nitride material region has a crack level of less than about 0.001 $\mu m/\mu m^2$.

35. The semiconductor device of claim 1, wherein the gallium nitride material region includes at least one laterally grown gallium nitride material layer.

36. The semiconductor device of claim 1, wherein a portion of the gallium nitride material region has a defect density of less than about 10^5 defects/cm^2.

37. The semiconductor device of claim 1, wherein the device is a light detecting device.

38. A method of forming a semiconductor device comprising

forming a gallium nitride material region over a substrate; and

forming a via extending from a first side of the semiconductor device, the via being free of an electrical contact formed therein.

39. The method of claim 38, further comprising forming the via using an etching process.

40. A semiconductor device comprising:

a silicon substrate;

a gallium nitride material region formed over the silicon substrate,

a first electrical contact formed over a portion of the gallium nitride material region; and

a second electrical contact formed over a portion of the gallium nitride material region;

wherein the semiconductor device has at least one via extending from a backside of the semiconductor device.

41. The semiconductor device of claim 40, wherein the first electrical contact is formed over a first portion of the gallium nitride material region and the second electrical contact is formed over a second portion of the gallium nitride material region, wherein the first portion and the second portion are on different planes.

42. The semiconductor device of claim 40, wherein the first electrical contact is formed over a first portion of the gallium nitride material region and the second electrical contact is formed over a second portion of the gallium nitride material region, wherein the first portion and the second portion are on the same plane.

43. The semiconductor device of claim 40, wherein the via is free of an electrical contact formed therein.

44. The semiconductor device of claim 40, further comprising a compositionally-graded transition layer formed between the substrate and the gallium nitride material region.

45. The semiconductor device of claim 44, further comprising a constant composition transition layer formed between the substrate and the compositionally-

graded transition layer, the constant composition transition layer comprising a gallium nitride alloy, aluminum nitride, or an aluminum nitride alloy.

46. The semiconductor device of claim 44, further comprising a constant composition transition layer formed over the compositionally-graded transition layer, the constant composition transition layer comprising a gallium nitride alloy, aluminum nitride, or an aluminum nitride alloy.

47. The semiconductor device of claim 40, wherein the semiconductor device is a light emitting device.

48. The semiconductor device of claim 47, wherein the semiconductor device is an LED.

49. The semiconductor device of claim 40, wherein the semiconductor device is a light-detecting device.

50. The semiconductor device of claim 40, wherein the via extends from a backside of the substrate.

51. The semiconductor device of claim 40, wherein the first and second electrical contacts are formed on a topside of the device.

52. A method of forming a semiconductor device comprising
forming a gallium nitride material region over a silicon substrate;
forming a first electrical contact over the gallium nitride material region;
forming a second electrical contact over the gallium nitride material region; and
forming a via extending from a backside of the semiconductor device.

53. An opto-electronic device comprising:
a silicon substrate;
a compositionally-graded transition layer formed over the silicon substrate; and

a gallium nitride material region formed over the compositionally-graded transition layer, the gallium nitride material region including an active region.

54. The device of claim 53, wherein the silicon substrate has at least one via extending from a backside of the substrate.

55. The device of claim 53, further comprising:
a first contact formed on a topside of the device; and
a second contact formed on a topside of the device.

56. The device of claim 53, wherein a backside of the device is free of an electrical contact.

57. The device of claim 53 further comprising a constant composition transition layer formed between the substrate and the compositionally-graded transition layer, the constant composition transition layer comprising a gallium nitride alloy, aluminum nitride, or an aluminum nitride alloy.

58. The device of claim 53 further comprising a constant composition transition layer formed between the compositionally-graded transition layer and the gallium nitride material region, the constant composition transition layer comprising a gallium nitride alloy, aluminum nitride, or an aluminum nitride alloy.

59. The device of claim 53, wherein the compositionally-graded transition layer comprises a gallium nitride alloy.

60. The device of claim 53, wherein the concentration of gallium in the compositionally-graded transition layer is graded.

61. The device of claim 53, wherein the concentration of gallium in the compositionally-graded transition layer is increased in a direction away from the substrate.

62. The device of claim 53, wherein the compositionally-graded transition layer comprises an alloy of gallium nitride selected from the group consisting of $Al_XIn_YGa_{(1-x-y)}N$, $In_YGa_{(1-y)}N$, and $Al_XGa_{(1-x)}N$, wherein x and y are greater than or equal to 0 and less than or equal to 1.

63. The device of claim 62, wherein the value of x decreases in a direction away from the silicon substrate.

64. The device of claim 53, wherein the transition layer comprises GaN at a front surface of the compositionally-graded transition layer and is free of gallium at a back surface of the compositionally-graded transition layer.

65. The device of claim 53, wherein the composition of the compositionally-graded transition layer is graded across the entire thickness of the compositionally-graded transition layer.

66. The device of claim 53, wherein the composition of the compositionally-graded transition layer is graded only across a portion of the thickness of the compositionally-graded transition layer.

67. The device of claim 53, wherein the device is an LED.

68. The device of claim 53, wherein the device is a laser.

69. The device of claim 53, wherein the device is a light detecting device.

70. A method of forming an opto-electronic device comprising:

forming a compositionally-graded transition layer formed over a silicon substrate; and

forming a gallium nitride material region over the compositionally-graded transition layer, the gallium nitride material region including an active region.

71. A method of forming a semiconductor structure comprising:
forming a first transition layer over a silicon substrate;
forming a gallium nitride material region over the first transition layer; and
removing the silicon substrate to expose a backside of the transition layer.

72. The method of claim 71, wherein the first transition layer comprises a compositionally-graded transition layer.

73. The method of claim 72, further comprising forming a constant composition transition layer over the compositionally-graded transition layer and forming the gallium nitride material region over the constant composition transition layer, wherein the constant composition transition layer comprises a gallium nitride alloy, aluminum nitride, or an aluminum nitride alloy.

74. The method of claim 72, further comprising forming a constant composition transition layer over the silicon substrate and forming the compositionally-graded transition layer over the constant composition transition layer, wherein the constant composition transition layer comprises a gallium nitride alloy, aluminum nitride, or an aluminum nitride alloy.

75. The method of claim 71, further comprising forming an active region in the gallium nitride material region.

76. The method of claim 71, wherein the semiconductor structure is a light detecting device.

77. The method of claim 71, wherein the semiconductor structure is a light emitting device.

78. An opto-electronic device comprising:

a transition layer comprising a gallium nitride alloy, aluminum nitride, or an aluminum nitride alloy, the transition layer having an exposed back surface; and

a gallium nitride material region formed over a front surface of the transition layer, the gallium nitride material region including an active region.

79. The opto-electronic device of claim 78, wherein the transition layer is compositionally-graded.

80. The opto-electronic device of claim 79, further comprising a constant composition transition layer formed between the compositionally-graded transition layer and the gallium nitride material region, the constant composition transition layer comprises a gallium nitride alloy, aluminum nitride, or an aluminum nitride alloy.

81. The opto-electronic device of claim 78, wherein the transition layer has a constant composition comprising a gallium nitride alloy, aluminum nitride, or an aluminum nitride alloy.

82. The opto-electronic device of claim 81, further comprising a compositionally-graded transition layer formed between the constant composition transition layer and the compositionally-graded transition layer.

83. An opto-electronic device comprising:

a transition layer comprising a gallium nitride alloy, aluminum nitride, or an aluminum nitride alloy;

an electrical contact formed directly on a back surface of the transition layer; and

a gallium nitride material region formed over a front surface of the transition layer, the gallium nitride material region including an active region.

84. The opto-electronic device of claim 83, wherein the transition layer is compositionally-graded.

85. The opto-electronic device of claim 84, further comprising a constant composition transition layer formed between the compositionally-graded transition layer and the gallium nitride material region, the constant composition transition layer comprises a gallium nitride alloy, aluminum nitride, or an aluminum nitride alloy.

86. The opto-electronic device of claim 83, wherein the transition layer has a constant composition comprising a gallium nitride alloy, aluminum nitride, or an aluminum nitride alloy.

87. The opto-electronic device of claim 86, further comprising a compositionally-graded transition layer formed between the constant composition transition layer and the compositionally-graded transition layer.

88. An opto-electronic device comprising:

a silicon substrate;

a gallium nitride material region formed over the substrate, the gallium nitride material region including an active region, wherein the active region has a non-rectangular plane-view cross-section.

89. The opto-electronic device of claim 88, wherein a non-active region of the opto-electronic device has a non-rectangular plane-view cross-section.

90. The opto-electronic device of claim 89, wherein the active region has the same non-rectangular plane-view cross-section as the non-active region.

91. The opto-electronic device of claim 90, wherein the non-active region is the silicon substrate.

92. The opto-electronic device of claim 90, wherein the non-active region is a layer.

93. The opto-electronic device of claim 89, wherein the active region has a different non-rectangular plane-view cross-section than the non-active region.

94. The opto-electronic device of claim 88, further comprising:

a first contact formed on a topside of the device; and

a second contact formed on a backside of the device.

95. An opto-electronic device comprising:

a substrate;

a gallium nitride material region formed over the substrate, the gallium nitride material region including an active region, wherein the active region has a non-rectangular plane-view cross-section; and

wherein a non-active region of the opto-electronic device has a non-rectangular plane-view cross-section.

96. The opto-electronic device of claim 95, wherein the active region of the opto-electronic device has the same non-rectangular plane-view cross-section as the non-active region.

97. The opto-electronic device of claim 95, wherein the non-active region is the substrate.

98. The opto-electronic device of claim 95, wherein the non-active region is a layer.

99. The opto-electronic device of claim 95, wherein the active region has a non-spherical plane-view cross-section.

100. The opto-electronic device of claim 95, wherein the active region has a different non-rectangular plane-view cross-section than the non-active region.

101. A method comprising:

forming an active region having a non-rectangular plane-view cross-section, the active region being a portion of a gallium nitride material region formed on a silicon substrate

102. The method of claim 101, comprising etching the active region to have a non-rectangular plane-view cross-section after forming a gallium nitride material region including the active region on the silicon substrate.

103. The method of claim 101, further comprising forming a non-active region having a non-rectangular plane-view cross-section.

104. A method comprising:

forming an active region having a non-rectangular plane-view cross-section, the active region being a portion of a gallium nitride material region formed on a substrate; and

forming a non-active region having a non-rectangular plane-view cross-section.

105. The method of claim 104, wherein the active region has the same non-rectangular plane-view cross-section as the non-active region.